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Title: e-Quality Control System & its effect in Upgrading the Standards of Flexible Pavements

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ABSTRACT

In this electronic age, the highways play a major role in the economic development of a country. So the quality of roads should be as per best available standards. Presently there is no fool proof system for monitoring the quality and quantity of the work. The existing system of quality control testing is time consuming and is not matching with the high speed of construction. Due to use of normal machineries, the existing tolerance limits permits higher range of variations for acceptance, which needs to be re-looked and modified with the use of e-quality control system. So, an e-quality control shall be developed in the flexible pavements which can ensure the quality & quantity of material as per desired standards. In this study, a methodology shall be developed to upgrade the machinery to have an electronic control on the various ingredients of the product. To increase the high speed of construction and ensure quality & quantity of the product, a model of e-quality control system shall also be developed using the Vehicle Tracking System, Fuel Sensor and Global Positioning System. The standards of riding quality shall also be upgraded accordingly.

Keywords: electronic sensor, e-control, flexible, Global Positioning System, Roughness, Vehicle Tracking System.

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1. Introduction

1.1 General

In the present age of electronic era, the development of the country is going at a very fast speed. The highways play a major role for the speedy & economic growth of the country which in turn improves the living standard of people. There is always a demand for better condition of roads, sufficiently wide, ensuring safe & speedy movements.

1.2 Transport System

An efficient transport system is a pre-requisite for the sustained development of a country. Road transport is the most widely prevalent and used system of transportation. Thus due attention is required at the time of construction of highway. The highway construction materials are carried through tippers, trucks etc. With the increase in the speed of highway construction, large quantity of constructional materials is required to be carried to the respective site. So in keeping pace with the speed of construction, an efficient transport system is required which has a great role to complete the project within its schedule time and save the cost that are wasted for lack of proper monitoring in planning of execution.

1.3 Quality Control

The quality control involves the acceptance criteria which includes the tests, frequency of testing and tolerance limits, inspections for critical examination of the work by selected tests to determine its conformity to specifications and action taken to ensure quality. Thus, the quality control system includes all those planned actions that are necessary to provide adequate confidence that the products or service will meet the requirements and is essentially a system of planning, organizing and controlling human skills to assure quality.

1.4 Monitoring of Vehicles

An optimum use of constructional knowledge and experience in planning, design, procurement, and field execution can only achieve overall project objectives. So a certain planning & system is required to an engineer for optimal utilization of transporting vehicles during construction of a highway project so that he can be able to take decision about how to control its future plan of

work more precisely. The proper monitoring of vehicles will also lead to a speedy economical construction. Intelligent Vehicle Highway Systems are currently a high-priority area of research and development in many countries and can make significant improvements in mobility, safety, and productivity of transportation systems by utilizing advanced technologies from electronics, communications, and computer science. There are many research thrust areas that are useful to both Vehicle Track System (VTS) and construction automation. In India, carrying of materials for construction of a proposed highway project are well defined but there is no monitoring system available to an engineer at present, to check the fuel consumption of vehicles at spot, to check the theft of fuel if any at any time, unnecessary halting of vehicles that leads the delay in completion of project, etc. All these factors directly affect the increase of total cost of the project when it is completed. The truck/tipper's drivers are habitual to make various halts on the way & are even known to sell the petrol/diesel of the vehicles being used. So, the transportation becomes more costly and vehicles take more time to reach their destination. Our proposed work deals with modeling of economical & efficient use of vehicles through e-control for construction of a highway, updating the machinery for monitoring quality & quantity of work in flexible pavements and effect of e-quality control system in upgrading the standards of flexible pavements.

2. Literature Review

The road development programmes envisaged for the country involves large amount of money, manpower, materials & machinery not only for construction of new roads, but for the improvement in the existing road network also. Road transport is the most widely used system of transportation. This mode of transport i.e. roads carry 85% of the passenger traffic and 70% of the freight traffic. So, a road network which is very efficient is required for the economic development of the country. In India, there are 4.1 Million km of roads out of which

National Highways (NHs) are 71,972 km, State Highways are 1,66,130 km, Major District Roads are 2,66,058 km and other roads are 36,05,633 km. The National Highways which are only 1.75% of total length of roads carry 40% of the traffic on the Indian roads. Peformance is a broad, general term describing how pavement condition changes or how pavement structures serve their intended functions with accumulating use (George et atl., 1989). AASHTO (2003) defines the pavement performance as the ability of a pavement to satisfactorily serve traffic over time. The highways play a major role in the economic development of the country. The economic growth of the countries like USA is 1.6%, UK is 1.1%, France is 1.7%, Canada is 2.2%, Japan is (-) 0.6% and India is 6.1%. On the other hand the annual growth of vehicles in India is 13% in case of cars, 5% in case of trucks and 78% in case of two-wheelers. Road transport is the most widely prevalent used system of transportation.

AK Mukherjee et al. (2001) defines that with the sophistication in the processing/production of the material as well as superior workmanship, it is desirable that the quality control should be more "Procedure specific" so that the quality of product would be ensured without hindering the progress. The nation will be benefited most by achieving high quality workmanship and in avoiding time and cost over-run. Control document of a large project is expected to have Quality Assurance System as a part of the contract. Aworemi et al. concluded that poor road condition, inadequate road infrastructure, absence of integrated transport system, drivers' behavior, accident and inadequate traffic planning are the factors responsible for road traffic congestion.

Eldin (1996) provides several examples of projects that have successfully used constructability to reduce project durations without increasing project cost. Constructability reviews of highway projects during design have the potential to minimize the number and magnitude of changes and delays during construction and thereby reduce durations (Anderson and Fisher 1997a). Dr. HC Mehndiratta et al. (2006) concluded that by using the mix of 70 per cent gravel and 30 per cent crushed aggregates there will be reduction in the cost of construction of pavement by approximately 32 per cent as compared to using crushed aggregate alone. With increasing client-imposed pressure on construction management teams to reduce schedule durations and decrease costs while continuing to produce a high-quality finished product, the value and importance of improving the management of construction supply networks remains

(Vrijhoef and Koskela 2000). There are also a plethora of constraints imposed on a typical construction project, such as weather, site conditions, availability of resources, schedules, and local laws and regulations, which are not common to the manufacturing industry (Koskela 1992; Biscoe & Dainty 2005; Cox et al. 2006; Salem et al. 2006).

Mahesh Kumar et al. (2012) concluded that for better quality control, berms and shoulders should be constructed and compacted along with each layer simultaneously. No vehicular traffic of any kind should be allowed on the finished wet mix macadam. Seat coat should be applied on DBM surface immediately i.e. prior opening it to the traffic. The bituminous layers should not be left open for the traffic without full overlay. Tim Martin et al. (2008) discussed the process and tools needed to estimate the remaining service life for roads by varying trigger values. Muralikrishna P et al. (2011) concluded that the remaining service life of the section can be increased by timely and appropriate selection of the maintenance treatment. By timely and appropriate maintenance, the deflection, roughness and percentage crack can be kept within allowable limits. Lee and Akin (2009) and Akcamete et al (2009) point out the limitations of manual processes in fieldwork and the lack of formal approaches to collect data during facility field operations resulting in poor quality data being collected at jobsites. Major activities include resource management (CII 2001; Proverbs et al 1995; Saidi 2003; Tommelein 1997), productivity analysis (El-Omari and Moselhi 2009; Kannan 1999; Oloufa et al. 2003), and quality management (Cheok et al. 2001; Gordon et al. 2007). Researchers have pointed out that approximately 40% of the time loss on worksites is owing to lack of materials, poor identification of materials, inadequate storage, and in general, bad management of materials, inadequate storage, and in general, bad management of materials (Baldwin et al. 1994). Poor material management leads to poor work planning and control, which in turn leads to delays in schedule and increased labor costs (Thomas and Sanvido 2000).

Apart from resource management and productivity analysis, researchers have pointed out the need of quality management at worksites because defects in construction are estimated to result in rework costs of up to 6-20% of construction cost (Josephson 1999; Patterson and Ledbetter 1998). Saurabh Taneja et al. (2011) concluded that an overview of applications of field data capture technologies & monitoring workflow in these operations. Monitoring of field personnel can improve safety standards at sites and also highlight any inefficient processes that are part of

an operation. S.Nazarian et al. (1998) discussed the nature, role, and feasibility of measuring the properties of flexible pavement material in the laboratory and in the field with different types of nondestructive methods and devices. Seismic methods measure the engineering properties of pavement materials. Seismic testing both in the laboratory and in the field is rapid and quite repeatable. Seismic modulus is sensitive to variations in moisture content and dry density of the base and prepared sub-grade.

For infrastructural development in large scale like PMGSY in India, the construction of roads in rural sectors is being envisaged on the basis of CBR result on subgrade soils (IRC:SP:20-2002; IRC:SP:72-2007). AASHTO Guide for Design of Pavement Structures 1986 is used to present the application of the proposed concepts. Quality-control data allow deficiencies to be detected during the construction of a pavement and can be used to adjust the original design whenever these deficiencies are deemed unacceptable. Victor Torres-Verdin et al. (1991) presented for use of quality control data to correct deficiencies detected during pavement construction. Once a pavement layer is finished, it is evaluated by means of a control parameter. If the evaluation indicates that the layer being analyzed does not meet design specifications, then improvements are made in the overlying courses so that a pavement structure with a performance equal to that of the original design structure is obtained at the end of construction.

BB Pandey (2008) concluded that guidelines for Design of Flexible Pavements as per IRC 37:2001 gives pavement thickness of 80 per cent reliability and upgradation to a higher reliability is suggested for high volume roads to reduce frequent interruptions for maintenance. Fatigue life of a bituminous layer can be increased up to ten times by increasing bitumen content and by decreasing air void. G. Suresh et atl. (2010) concluded that the use of modified bitumen has shown a reduction in optimum bitumen content and increase in stability in SDBC mix prepared using crumb rubber modified bitumen compared to SDBC mix prepared using neat bitumen. K. Ganesh et al. (2010) – Automatic wheel tracking immersion equipment has been successfully tested for bituminous beam specimens subjected to various wheel loads and number of passes. During 1960s, Zube reported that dense graded pavement became excessively permeable at places of air voids above 8 per cent. K.Kantha Kumar et al. (2008) - The air void content of the mix specimens has a significant effect on the volumetric properties,

resilient modulus, tensile strength, fatigue and irrecoverable deformation behaviour. Bituminous Concrete mix with lower air void content tends to offer longer fatigue life and high resistance to permanent deformation.

In the late 1950s, systems of objective measurement (such as roughness meters, deflection and skid test equipment) began to appear that could quantify a pavement's condition and performance. Arunachalam (1971) carried out an analysis of extensive field investigation data for evaluating strengthening requirements both by California Bearing Ratio test values and also using Benkelman beam rebound deflection methods. The analysis shows that the deflection method gives realistic results in consonance with pavement performance and is more reliable than CBR method.

Recent studies by Jain indicated that reduced thickness of surfacing could be used if modified bitumen is used in bituminous courses of flexible pavements. The predicted life of surfacing with 80/100 bitumen is 6-8 years while predicted life of surfacing with NRMB-70 is 9-10 years. Prithvi Singh Kandhal (2008) concluded that the use of Bituminous Macadam a very popular mix at present may be deleted and substituted with DBM. Similarly, semi-dense Bituminous Concrete should be substituted by Bituminous Concrete. The Profile Corrective Course (PCC) should be only in DBM or BC. The confidence in the construction supply network could be increased with improved supply network visibility; the necessity for large on-site buffers of materials could potentially be reduced (Christopher and Lee 2004). The integration of automated materials locating and tracking technology (AMLTT) within the construction supply network has the potential to enable such a change. Materials management, in general, is focused on ensuring that the right materials are available for work crews at the right point in time (Kini 1999; Construction Industry Institute 1999). Over the past decades, the overall process of construction materials management, especially, on large projects, has received significant attention (Construction Industry Institute 1986; Kini 1999; Thomas et al. 2005).

Peurifoy et al. (1996), Nunnally (1987), and Caterpillar (1995) have dealt with various aspects of economics and productivity of construction equipment. Douglas (1975) explored the economics of construction equipment in detail. Vorster (1980) studied the age-cost-reliability

relationship and the organizational aspects of managing construction equipment. As for productivity, Kannan (1999) demonstrated the use of onboard instrumentation as a method to collect field data autonomously and, hence, built an experience database of site productivity. The autonomous data also provided the statistically required distributions for simulation of site operations. Hildreth (2003) demonstrated the use of a global positioning system (GPS) for identifying events that occurred on a construction job site and, hence, collected data autonomously. Martinez (1996) provided a general-purpose simulation tool that could model a complicated project situation and, hence, studied the productivity of a fleet of equipment.

Internet-enabled, remotely controlled cameras installed at project locations, also referred to as webcams and surveillance cameras, have become prevalent over the last 10 years (Hannon 2007). Research by the National Cooperative Highway Research Programme (NCHRP) in 2007 reported the advancement of fixed camera systems from either a single camera per project location or multiple independent cameras per project site to the development of "a networked robotic camera system" in which cameras have robotic features and improved image resolution capability (Hannon 2007). Silva et al. (2009 a) reported that declining construction productivity is resulting from inadequate supervision. Highway organizations lost creditability and time is often taken defending deviation from the published program (Flyvbjerg et al. 2002). Thus, cameras that take digital images or videos are part of important tools for managing construction projects (Brilakis 2007). Digital images may also reduce time needed for inspection by allowing this task to be done remotely (Brilakis 2007). Seeing real-time weather can help project managers to plan and schedule accordingly.

RFID is a segment of automated identification technology that used radio waves to capture and transmit data regarding the state of different objects, persons, or beings (Jaselskis and El-Misalami 2003). The use of RFID in the construction industry was first widely proposed in the mid-1990s, but like other industries at the time, the technology was not widely pursued because of the high cost of implementation & lack of technology standardization (Jaselskis et al. 1995). Moving forward, the research community began to focus specifically on determining the ability to accurately identify and track key material and equipment using RFID in typical construction environments (Goodrum et al. 2006; Song et al. 2006). Researchers commonly cited a number

of problems, ranging from a lack of standardized data and equipment to the need for members of the construction industry at all levels to be introduced and exposed to RFID (Goodrum et al. 2006; Song et al. 2006). With the ability of RFID to perform in a construction environment established, researchers continue to put forth efforts in developing algorithms that integrate the location information captured from GPS and the identity-related information captured by using RFID (Song et al. 2006; Caron et al. 2007; Torrent and Caldas 2007). Ergen et al. (2007) discuss the results of a field trial in which an RFID-based AMLIT system was employed in locating material in a fabricator's laydown yard. CII (2008). The AMLTT system was found to be a viable means of improving the ability to locate key items in a variety of operating conditions.

Jaselskis and El-Misalami (2003) presented a process for using a RFID system, which they implemented on an industrial plant construction site, to identify pipe supports. Song et al. (2006a) combined RFID and global positioning system (GPS) technologies to identify the location of materials on a construction site. Song et al.(2006b) also evaluated the feasibility of using RFID technologies to track pipe spools in an industrial construction project. Ergen et al. (2007a) applied RFID technologies to streamlining information flow for life-cycle data management. Goodrum et al. (2006) developed a system to automatically track construction tools using active RFID tags. Chin et al. (2008) presented a strategy to combine RFID and four dimensional computer-aided design technologies to monitor the progress of structural steel works. Ergen et al. (2007b) presented an integrated system of RFID and GPS for tracking and locating precast concrete panels in a construction site. These studies advance construction material management by automating the process for identifying and tracking the location of construction resources. Sayers et. al. (1986) correlated the unevenness indices obtained from the fifth wheel BI running at different speeds such as 20, 32 and 50 km/h with those obtained from other roughness measuring equipments. They concluded that the speed and roughness were inversely proportional to each other. Bennet (1996) has also demonstrated this fact with graphical inference. Jordan and Young (1980) developed the equation for establishing the roughness values expected under standard conditions as a function of roughness observed at different speeds. Ever increasing road roughness results in rapid pavement deterioration because of increased pounding action of heavy loads. As a result, it affects the speed of

vehicles, safety and comfort of passengers and also the surface drainage characteristics of the pavement surface. Among the various instruments, Towed Fifth Wheel Bump Integrator (TFWBI) is the most popular equipment being used by several developing countries because it is affordable, simple and also needs less frequent maintenance and calibration.

AK Sandra et al. took the study with the objective to develop the relationship between the roughness values obtained at different operating speeds ranging between 10 and 50km/h with those obtained at the standard operating speed of 32 km/h based on data collected at selected stretches on different kinds of roads. On uneven surfaces, the roughness of the road is inversely proportional to the operating speed of the vehicle. On even surfaces, the speed of operation does not have much effect on the roughness values. Peter Mucka et al. (2012) concluded that the results of comprehensive analysis of the old and remixed high-way lanes as per International roughness index do not significantly reflect the objective ride quality change of the remixed new lane, as it remains rather constant. Ministry of Road Transport & Highways has clearly defined in specifications for Roads and Bridge Works the permissible variations in gradations as per clause 406.2.12 for WMM, 507.2.5 for DBM & 509.4.1 for BC. The permissible variations from Job Mix Formula are defined in Cl. 507.3.4 which includes variation for binder content also. For riding quality, the roughness in each lane should not be more than 2000mm/km in a km length.

3. Description of Broad Area/Topic

3.1 e-Quantity Control of Materials

With the large speed of construction, the quantities of material used in construction are very large. It is very difficult to manage the quantity of each material at all the stages of construction and hence the existing system is not giving us the confidence that full quantities have been used. Now-a-days it is a great problem to an Engineer in construction of a highway. So, it has become requirement of time to have a system in the highway construction which can control the quantity of materials in the highway construction more precisely and at the same time at a very fast speed. Thus the perfection of use of all materials in highway construction through e-quantity control modeling can only assume the quantity of all materials used in the said work as per required standards laid down in the agreement.

3.2 e-**Quality Control Testing**

In the present electronic age, everyone wants everything perfect to the best available standards and at the same time at a very fast speed. The road users want to travel on high quality and safe roads at a very fast speed. In the present system the quality control tests are physically conducted at site and are time consuming. The numbers of tests prescribed in the codes are more which are difficult to achieve. The contractor does not engage requisite staff for the quality control tests. Sometimes the staff engaged on contract does not take interest in the quality control tests and the tests are not conducted at site & only bogus entries are made in the prescribed registers. The contractor simultaneously starts works on different roads of different departments such as PWD (B&R) & Marketing Board etc. and counts the same tippers of material on both the sites to use less quantity. The departmental staff deployed for the execution of work mixes up with the contractual agency and sub-standard work is accepted. There is no fool proof method to check that 100% material has been used. So, the present system of quality control is neither perfect nor matching with the speed of construction of work. In keeping pace with the speed of construction, the age old quality control methods needs to be reviewed and substituted with modern methods of quality control and quality assurance. Obviously e-Quality control tool can only be suitable tool to solve the above problems.

3.3 **Limitation in Machineries**

For the construction of a highway with normal machinery, one cannot have any control on the various ingredients of material used. This non-control on the preparation of mix on material used in the construction of a highway gives a poor quality of road which further results into more expenditure on maintenance. Until and unless, the various ingredients which are required as per job mix formula or specifications are not well controlled at the initial stage of preparation of mix, the quality of the product cannot be assured. To achieve the best quality & uniformity in production, an updation of old aged equipments is most essential.

3.4 **Standards for Tolerances & Riding Quality**

In the existing codal provisions/specifications, the tolerance limits have been given, so that the contractor can set up the plant to get the percentages of the various ingredients in the actual mix as per job mix formula within the permissible limits of variations and the material is accepted

within these tolerance limits. In this electronic age, the modern equipments are used which automatically control the various ingredients of product and check the quality of product. So, in the highway construction where e-quality control system has been adopted, the quality & quantity of the work as per standards is assured. To upgrade the standards of highways especially in the case of a high speed corridors where a better riding quality is required, the tolerance limits need to be relooked and revised tolerance limits (lower than the existing) should be allowed. The acceptable limits of riding quality should also be upgraded.

4. Problem Identification/ Objectives of Study

4.1 Quality & Quantity with Pace of Construction of Highways

With the fast development of country, the construction of Highways has increased manifold in the country. The quality and quantity of materials used in construction of highway play a vital role for economical development of a country. In this electronic era, with the use of new technologies the riding quality of roads is improving day by day, but there is no tool available to an Engineer that can give assurance that full quantity of materials has been used conforming to the specifications. Similarly, in addition to the wide and efficient road network, the quality of the roads should be as per best available standards. Presently, the quality control tests are conducted physically in the field in three style and steps. During execution, the contractor sets up a field laboratory as a mandatory of his agreement and carries out all the quality control tests as per requirement of his agreement. To satisfy the data/results of said contractor, the quality control tests are being again conducted by the Govt. Engineer or field staff who has deployed for the execution of said work and finally it is re-confirmed by the quality control department as a third party. All tests are very large in number and take lot of times for getting satisfactory certificate from all. Even doing all measures there is no fool proof method to check that material has been used at site as per desired standards and quantities. So, a tool/model is required that includes all those planned actions that are necessary to provide adequate confidence that the product meets all the requirements and is confirming to the specifications. Our proposed e-quality control tool can solve this real life field problem of an Engineer more precisely.

4.2 Machineries in Construction with Electronic Devices

Like as quality of materials, the working quality of equipment has also a vital role for upgradation of road quality in the best level. The normal machinery used for the construction of a highway does not have any check on various ingredients of material used in the construction that ultimately leads the poor quality of road which further results into more expenditure on maintenance. The malpractices of use of less quantities of material especially bitumen being costly one by the agency is a common phenomena in highway construction and thus the quality of the product cannot be assured. With fast development and huge investment in highway sector, the road construction is becoming equipment oriented. For a better control on the quality, the machinery used for construction of highways should be updated by e-quality control electronic device so that the above malpractices of any agency can be checked and upgrade the quality of product in the field.

4.3 Tolerance Limits in Flexible Pavements

The tolerance limits in the existing codes have been kept keeping in view the normal system of quality control and permits higher range of variations for acceptance. Now, in our proposed system where all the activities of a highway construction are electronically controlled and also will assure the quality and quantity of the work, the tolerance limits prescribed in the existing codes needs to be re-looked and revised so as to accept the best quality work using optimum quantity of materials in optimum time period.

4.4 Objectives of Study

Basic objective of proposed research work shall revolve around:

i. To develop e-quality control system which will control the quality & quantity of the work more precisely.
ii. Modeling an optimization network of vehicles for economical & efficient use of those vehicles through e-control for best construction of a highway.

iii. To update the machinery equipments by electronics devices for monitoring quality & quantity of a pavement as the normal machinery cannot control the various ingredients of the product.

iv. To upgrade the standards of tolerance limits in flexible pavements as the existing standards has been kept keeping in view the normal system of quality control which permits higher ranges of variations.

v. To modify the acceptance criteria of sample testing in the construction of a highway as the existing criteria of conducting physical testing is time consuming and not matching with the high speed of construction.

vi. To upgrade the standards of riding quality of a flexible pavement as with the use of e-quality control system a better riding quality is expected to be achieved.

5. Methodology to be Adopted

5.1 Development of e-Quality Control System

An e-Quality Control System shall be developed in such a way so that the live data at various stages of construction from site is directly placed in it along with live photographs. A special format will be designed for each activity of the construction stage so that live data can be placed in these prescribed formats. The system will be so developed that no manipulation in data can be possible at a later stage. All the relevant data collected at site at various stages of construction is likely to be placed on web site in live time in respect of on receipt of bitumen at site, on mixing of bituminous material at plant site, on weighing at bridge site, on movement of vehicles, on work site and on testing of materials.

5.2 Upgrading of Machinery

With fast development and huge investment in highway sector, the road construction is becoming equipment oriented. For achieving best quality and uniformity in production, the modern equipments with in-built e-control will be installed to control the quality of the product. Some of the modern equipments to be used are batch mix type Hot Mix Plant with electronic sensor which automatically controls proportion of different fractions and bitumen, cone crusher (integrated stone crushing & screening plant), automatic Wet Mix Plant with moisture content controller, concrete Batching & Mixing plant with automatic control, crushing and processing

plant for GSB material, automatic weighing machine, paver finisher with electronic sensor, vibratory road rollers/compactor and Nuclear Density Meter, Total Station & GPS etc.

5.3 Project Selection and Site Arrangements

A project will be selected to carry out the work in field. GPS and cameras will be installed at various desired locations at site. A laptop enabled with camera and GPS instrument will be given to every Engineer conducting tests in the field. The Vehicle Tracking System (VTS) will be installed in various vehicles along with various devices such as vehicle diagnostic sensors, fuel sensor & Global Positioning System (GPS) etc. VTS will also be used for tracking the vehicles and for making various other controls. The system will check the fuel consumption of vehicles in addition to check on the halt period of the vehicles etc.

5.4 e-Control on Quality & Quantity

The following controls are likely to be made at various stages of construction:

5.4.1 e-Control on Receipt of Bitumen

Generally the bitumen is received from the oil refineries. It has come to notice that in some cases, the bitumen tankers issued from the refinery do not reach the site & are sold in the open market and bitumen is received only in papers. So, it was felt necessary to have a control on the receipt of bitumen from various sources. To control this pilferage of bitumen, the photographs of the bitumen tankers shall be taken with the camera installed at site during its weighing on automatic computerized weighing machine and the details with project ID will be placed in live time on the website. With this the complete history indicating Tanker No., Indent No., Weight of loaded and empty tanker with line photograph etc. of the bitumen received from the Refinery is available on the website which will be attached with the forthcoming bill of the agency as documentary evidence. So, this process will make a complete check on the receipt of bitumen.

5.4.2 e-Control at Weighing Machine Site

All the tippers used for carrying out the mixed material from plant site to work site are brought to the weighing machine to carry out the weight first when it is empty and secondly when it is filled with mixed material. A camera & GPS instrument will be installed at the automatic weighting machine site to have the photograph and location of vehicle. The live data so taken

indicating tipper no., project ID, type of material, empty & loaded weight of tipper along with photograph etc. is placed on web site in real time. Thus, with the e-control on weighing machine site, the material to be transferred from plant site to work site is fully controlled and we are well aware that how much material is being sent to work site.

5.4.3 e-Control on the Mixed Bituminous Material

To check the quality of the product, it is very essential to have a check on the ingredients of the mixed material. The proportions of various ingredients required for Bituminous materials will be set on the computer of batch type hot mix plant. Then the live data along with photographs will be placed on web site indicating tanker no., project ID, tipper no., type of material, temp. of bitumen, aggregates & mixed material, %age of bitumen etc. So, the complete details of various ingredients temperatures, %age of bitumen at mixing stage etc. are known and controlled at plant site. Thus, this part will make a complete check on the proportion of various ingredients, temperature etc. in the mixed material at the production stage.

5.4.4 e-Control on Vehicles

The VTS will be installed in all vehicles and synchronized with the system of e-quality control. It will check the route of the vehicle at all the times and will also have record of fuel consumption, kms travelled in a day, working hours per day, halt hours of vehicles/day, idle hours of vehicle/day & speed of vehicles etc. It eliminates the intention of the contractual agency which simultaneously starts work on different roads of different departments such as PWD, Marketing Board, and Municipality etc. and tries to count the same tippers on both the sites. Thus, with e-control, the location of every vehicle will be known at all the times and its route map can be checked. The vehicles can be fully managed and controlled by sitting in the office. It will give substantive savings in the consumption of fuel.

5.4.5 e-Control on Work Site

On the start of the work with a particular tipper, its photograph during unloading in the hopper of paver is taken and the location (Reduced Distance) is also noted with GPS. The data indicating tipper no., project Id, weight & temp. of mixed material, RD of start reach along with photograph is placed on website in time. The same exercise is repeated at the end point where material of this particular tipper finishes. This data will also be compared with the data placed

at website from the weighing machine site to know the material sent to work site. It will have a check that whether full material has reached at work site or not. All these details will be attached with the bill of the agency. So, the e-control at work site will ensure that the desired material has reached at work site and consumed as per requirements/standards. The system will also keep the RD wise record of material used from a particular tipper.

5.4.6 e-Control on Testing

One lap-top enabled with camera and GPS instrument will be given to every Engineer conducting the test. During the test, the live data will be placed on the web site along with location and photograph of the person conducting the test. The person conducting the test shall make a line entry on the website at all the various stages of test performance. Thus, e-control on testing will eliminate the intention of making bogus entries of testing and gives the assurance that the tests are actually performed at site as the engineer shall have to go to site and conduct the test as his photograph with camera and location with GPS are placed on website in live time.

5.5 Experimenting to Generate Test Results

A number of test conditions would be planned before hand and then operated to make required combinations. The outputs would be compiled into the format needed. Wherever needed, sampling would be done. If needed, the modification shall be carried out accordingly.

5.6 Verification of Test Results

The outputs generated would be subject to various verifications especially with the readily available and established outputs. The variations, if any, at all stages would be carefully noted and would then be placed on record. At any stage, if felt necessary, the findings would be shared with other eminent personalities so as to fine tune the research work and eliminate unnecessary entities.

5.7 Formulating the New Standards for Flexible Pavements

The data gathered through e-quality control system shall be further processed. The system will ensure the usage of full quantities of material. In the codal provisions/specifications, the tolerance limits have been given, so that the contractor can set up the plant to get the percentages of the various ingredients in the actual mix as per job mix formula within the

permissible limits of variations and the material is accepted within these tolerance limits. The present design standards will be reviewed and new standards will be developed & experimented in the field. The data so collected shall be analysed in detail. The newly developed highway standards for flexible pavements will be compared with the existing standards especially in reference to its standards for riding quality and tolerances etc. The revised tolerance limits which will be lower than the existing limits and other parameters will be developed.

6. Proposed/Expected outcome of the Research

The following outcome is expected from the research:

(i) e-quality control system will assure execution of work as per required standards & specifications more certainly.

(ii) A system will be developed which will automatically control the quality and quantity of the work.

(iii) Modeling for economical and efficient use of vehicles through e-control will give better perfection of quality of the highway construction.

(iv) Updation of machinery will ensure that there is no pilferage & full material has been used at site.

(v) The standards of flexible pavements will be upgraded with the use of e-quality control system especially in reference to riding quality and tolerance limits etc.

7. Proposed Time Frame (Gantt Chart)

The proposed time frame is shown in the Gantt Chart as below:

Phase	Proposed activities of mine	Month											
		1st	4th	6th	8th	10th	12th	14th	16th	18th	20th	22nd	24th
1	Literature Collection/Review												
2	Rigorous study & analysis												
3	Developing e-quality control tool/model												
4	Experimentation												
5	Results analysis and Publications												
6	Modifications, if any, of any tool/models and publications												
7	Draft writing (chapter-wise, time to time)												
8	Final thesis writing												

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